Results, challenges, and opportunities from the mathematical (far) side.

Alain Goriely (on behalf of maths)
Topics
- Multiple phases
- Dislocations
- Fracture, Plasticity
- Elasticity
- Energy & Industry
- Porous media

Methods
- Modelling/Mechanics
- Variational methods
- Nonlinear PDES
- Differential Geometry
- Experiments
- Numerical analysis

Newcomers:
- Dr Derek Moulton (mech bio)
- Dr Ian Hewitt (geosciences)
- Prof. John Wettlaufer (geo/mech/ice/…)
- Prof. Steve Shkoller (interface)

Visitors:
- Prof. Richard James (Minnesota)
- Prof. Adriana Garroni (Rome)
- Prof. Andrea Braides (Rome)
Phase transformations

Martensite-Austenite
Nematic elastomers
Plasticity, fracture

Quasiconvexification
Nonlinear elasticity
Variational methods

Pierluigi Cesana
Anton Muehlemann
Kostas Koumatos, John Ball
Phase transformations

Martensite-Austensite
Nematic elastomers
Plasticity, fracture

Quasiconvexification
Nonlinear elasticity
Variational methods

Pierluigi Cesana
Virginia Agostiniani

Clamped stretched elastomer
Dislocations

Discrete level
Semi-discrete
Mesoscale
Continuous

Discrete models
Variational models
Discrete to continuum
Strain-gradient theory
Differential geometry

Adriana Garroni, Pierluigi Cesana
Jon Chapman and Cameron Hall (discrete-continuum)
Thomas Hudson (dislocation dynamics)
AG (Continuum distribution)

Star-disclinations in Lead Orthovanadate
Photovoltaics
Li-ion battery
Extreme plasticity
Fibre materials

Modelling
Optimisation
Mechanics/Materials

Victor Burlakov, Jon Chapman, Colin Please, AG
Photovoltaics - Energy - Industry

- Photovoltaics
- Li-ion battery
- Extreme plasticity
- Fibre materials
- Indentation
- Wrinkling
- Brake Squeal

- Modelling
- Optimisation
- Mechanics/Materials
- Homogenisation
- Wave

Peter Howell-John Ockendon, Hilary Ockendon, Dominic Vella
Some thoughts on Mathematical Mechanical Biology

Bell, Gadelha, Fletcher, Kimpton, Lessinnes, Spill, Woolley, Zubkov.

Baker, Chapman, Gaffney, Oliver, Maini, Please, Sobey, Vella, Waters, Whiteley, AG
Growth
Remodelling
Anisotropy
Active stresses
Fluid-structure

Diffusion
Thermal
Electrochemical
Optical effects
Magnetic effects
Electric effects

Morphoelastic rods

Cardamine Seed expulsion

Passive slab
Cardiac cells

Thomas Lessinnes, Moulton, AG
Morphoelastic rods

Seashells

Derek Moulton, AG

Flagella

Hermes Gadelha, Gaffney, AG
Morphoelastic membranes

Blebbing

Thomas Woolley, Waters, Baker, Gaffney, Oliver, AG
Growth
Remodelling
Anisotropy
Active stresses
Fluid-structure

Diffusion
Thermal
Electrochemical
Optical effects
Magnetic effects

...
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Electrochemical
Optical effects
Magnetic effects
...

Brain Swelling

Georgina Lang, Vella, Waters, AG
BRAIN WORKSHOP, 13-14 January
Tissue Engineering
Cancer Modelling

Growth
Remodelling
Anisotropy
Active stresses
Fluid-structure

Diffusion
Thermal
Electrochemical
Optical effects
Magnetic effects
...

Figure 1: Capillary network around tumour

Cells within scaffold
Biomaterial scaffold
Perfusion bioreactor

Helen Byrne, Sarah Waters, Baker, Maini, Chapman, Gaffney, Please, AG, ...
There is no mathematical theory of mechanical biology

Challenges
Spatial scales
  (DNA to communities)
Time scales
  (mechanical to evolution)
Information

Opportunities
Discrete-to-continuum,
Homogenisation,
Thermodynamics

General framework?